# PATENT SPECIFICATION

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383,295

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COMPLETE SPECIFICATION.

## Improvements in Drive Chains.

(A communication from abroad from the LINK-BELT COMPANY, a corporation of the State of Illinois, with its principal office at 910, S. Michigan Avenue, Chicago, Illinois, United States of America.)

I, ARTHUR FREDERICK BURGESS, a British Subject, of the firm of Lloyd Wise & Co., of 10, New Court, Lincoln's Inn, in the County of London, Chartered Patent Agents, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

My invention relates to improvements in power transmitting or drive chains of the kind in which the articulations between the tension members include means for resisting lateral deflection and consequent thrash in the chain during running.

A chain of this type according to my invention comprises, broadly, a plurality of tension members joined together by pivot pins upon which said tension members are articulated, said tension members being apertured to embrace said pivot pins and each of the latter being so related with the tension members that it has two pivot axes about which articulation of the said tension members can take place, said two pivot axes being located on opposite sides of the neutral tension line of the chain and the line joining said axes being approximately perpendicular to said neutral tension line.

In the preferred way of carrying my invention into practice, I make the pivot pin receiving apertures in the tension members longer in a direction perpendicular to the chain than in a direction parallel with it and the ends of such apertures are bounded by cylindrical surfaces and joined by tangent surfaces, which latter generally intersect the axis of the chain; moreover each pivot pin conforms generally to the shape of the aperture and is adapted to rock to a limited extent therewithin, to limit relative angular displacement of the tension members.

While my invention is perhaps especially applicable to chains of the so-called silent type, that is chains built up of a series of overlapping toothed plates or links pivoted together, it is obvious that my invention in whole or in part is equally applicable and equally valuable in connection with other types of power transmission chains.

It is known that power transmission chains especially as applied to automotive uses, as, for instance, front end drive and the like, are extremely sensitive to vibration unless they be specially constructed to resist thrash. A free length of ordinary chain under tension between the wheels or sprockets will build up thrash or whip through resonance, such a length of chain being sensitive to transverse vibrations like the strings of a harp for the same well-known physical reasons.

Excessive whip or thrash causes noise and wear and results in greatly increased chain tension, increases joint action, causes impact with the wheels or sprockets and, because of these difficulties, not only wears out fast but absorbs an excessive amount of power while doing so. These objections are especially important in connection with certain commercially very important classes of use such as the drive in automotive motors from crank shaft to cam shaft or other motor auxiliaries.

We may, for instance, have a delicate sensitive drive of five horse-power capacity on the front end of a relatively heavy seventy horse-power motor with its correspondingly heavy inertia effects and the relatively light drive has then to contend with vibrations and variations in angular velocity of shafts of different frequencies at different motor speeds.

Chain made according to my invention not only overcomes the objections in question but also shows minimum elongation through wear, lends itself to maximum strength and gives smooth action, all of which are of the utmost importance in connection with modern automotive practice.

As a chain travels about two or more sprockets with straight reaches of chain between the sprockets, there is always a tendency for the chain to deflect between the sprockets from the straight line join-

ing the points of entry and exit with respect to adjacent sprockets. This tendency is a consummation of many small forces tending to deflect the chain. These impulses or forces that easily cause deflection are not ordinarily of great magnitude but they are often of a frequency that occurs with a natural vibrating period of the part of the chain involved and consequently the magnitude of deflection or whip in the chain will build up as a result of the repeated application of such forces,

I provide means inherent in my chain design to resist from their inception all such forces and to minimize their action before they have had time to build up the accumulative effect which ultimately results in disadvantages and thrash and whip. The articulated links of my improved chain may be toothed or not. They may have rollers or not; they may have blocks or not, as the case may be, but in all cases these links or tension members are articulated on pivot pins, with or without liners, which pins are so arranged that each pin has two points of articulation one or the other of said points coming into operation according to the direction of deflection of the chain. These points both normally lie outside of the normal line of tension of the chain on opposite sides thereof and, as aforesaid on a line substantially perpendicular to said normal tension line. These points of articulation are joined by relatively extended bearing surfaces between chain link and pivot. These relatively extended bearing surfaces carry the load when the chain is moving along a straight line. When the chain is deflected from its normal straight line path, the point of articulation in the direction of deflection, located, as it is, at a point relatively widely removed from the axis of the chain, comes into operation and causes a transference of the line of pull from the centre to a point beyond the line of what was previously the line of pull and this gives the tension of the chain a lever arm about which to work in its efforts to return the chain to the normal or neutral position. This happens every time the chain starts to deflect, so that there is a constant pressure on the chain resulting from these outwardly spaced articulation points tending to urge the chain back into line. The relation of the points of articulation with the link and shape of the pin and link are such that this resistance continues and it is a flexible resistance, not a positive one up to the point where the chain is by the limiting shape of the related parts positively prevented from further deflection.

My invention thus provides three things,—first, yielding means for preventing deflection, which yielding means go into effect instantly upon the commencement of a deflection excursion; second, positive means for limiting deflection, which means do not interfere with chain operation and chain articulation around the sprockets but do prevent excessive deflections; and third, the provision of an increased bearing surface between chain and pintle which is effective normally during the time the chain is under tension.

I have used the term lateral deflection. By this I mean deflection in a direction perpendicular to the axis of articulation of the individual link or links involved and perpendicular to the line of movement of the chain. It will be understood, of course, that the chain having left the sprocket wheel may move longitudinally in a direction perpendicular to the pintle and generally parallel with the axis of the individual link. This is the longitudinal movement which the chain is expected to perform. It may also move transversely in a plane containing the individual pintles. Chains are ordinarily wider in a direction measured parallel with the pintle than in a direction perpendicular to it and the pintle chain link relation itself is normally sufficient to take care of such movement, but it is the movement of the chain perpendicular to the pintle and perpendicular to the line of movement of the chain which causes the thrash or whip to which I have referred and it is this movement to which I refer when I use the word "lateral deflection".

I am aware that it is old to have so called stiff back chains, that is, chains which can deflect only in one direction but are free to bend in the opposite direction. Such chains as that are not entirely satisfactory for the purpose for which my chain is intended because if you have anything in the chain to positively and suddenly stop all deflection, you get a situation where the chain is under some circumstances too stiff, and may actually be thrown off the wheel. It is necessary to have the yielding cushioning means coming into effect first and followed up by the positive stop effect. Sometimes the positive stop might be dispensed with but the cushioning means under ordinary circumstances should be present. Further it is desirable to have this operation effective in both directions. A pendulum moves in two directions from the neutral line and if the vibration or deflection can be resisted both coming and going, maximum damping effect is produced.

Since my invention is illustrated in the accompanying drawings as primarily

adapted for use in connection with silent chain, I have referred to it in the detailed specification and discussion in terms of silent chain but it is to be understood that this reference to silent chain is for the purpose of illustration only and I do not desire to have my claims limited to, nor do I consider my invention as limited to, silent chain alone.

As power transmitting chain winds onto or off of the driving and driven sprockets and gears with which it is related, there is a tendency always for the chain to have imparted to it a lateral vibration due to the so-called chordal action of the sprocket teeth. It comes from the tendency of the chain to remain wound about the gear. It comes from the vibration of the machinery with which the chain and sprocket are associated. It may come from movement of the vehicle carrying that machinery, the relative weight of these tendencies and other tendencies toward vibration resulting from many other sources, may vary with the resistance but under all circumstances when a chain is in operation, either running idle or under load, the chain does tend to vibrate just as a violin string vibrates between its two points of support. The mere fact that the chain is traveling between these two points of support does not change this situation, while resonant action may add to the difficulty by greatly increasing the vibratory effect.

Especially owing to the resonant effect, the best time to stop vibration is when it starts and that is the time when the tension in the chain is least well able to stop it. It will be understood that when the chain vibrates as does a violin string, when it moves a sufficient distance beyond the neutral line between the two points of support, the tension on the chain working through the chain tends to pull the chain back into neutral line. But this effect only makes itself felt when the chain is so far out of line that the forces are working through a substantial lever arm. It will be seen that I minimize vibration or lateral displacement of the chain by providing such a relation between the pintle pin and the chain link that as the chain moves to one side or other from the neutral line, the center of articulation about which the links rotate will be displaced further to one side than is the line of tension in the chain, thus furnishing a mechanical advantage instantly available upon any deflection of the chain tending to force the chain back into line.

My invention is illustrated more or less diagrammatically in the accompanying drawings, wherein:—

Figure 1 is a side elevation in part section of a length of chain made according to my invention;

Figure 2 is a plan view partly in section of the chain shown in Figure 1;

Figure 3 is a side elevation showing a pair of links with pivot pin in section arranged for straight line tension;

Figure 4 shows the links at position of maximum front bend,

Figure 5 shows the links at position of maximum back bend;

Figure 6 shows a pinion in section with chain in elevation and part section winding onto it;

Figure 7 is a diagrammatic enlarged section through the pintle showing the outline of the aperture;

Figures 8 and 9 are diagrammatic views illustrating the way in which the double point articulation affords resistance to chain deflection in a straight line;

Figure 10 is a side elevation in part section and

Figure 11 a plan view in part section showing my invention applied to a chain with a liner;

Figure 12 is a view similar to Figure 10 but showing the chain in a front bend condition;

Figure 13 is a side elevation showing some of the links of a chain illustrating a slightly modified form;

Figure 14 shows a further modified form.

Like parts are indicated by like characters throughout the specification and drawings.

The chain is made up of a plurality of overlapping toothed links A $A^1$. These toothed links are joined in articulated overlapping relation by the pins $A^2$ which extend clear across the width of the chain and hold adjacent toothed links in working relation. The teeth on the links engage teeth on the sprocket $A^3$ and, so far as my present invention is concerned, it makes no difference what kind of contact there may be between the chain teeth and the sprocket or gear teeth. It may be inside, outside or a combination of both and contact may be with one tooth only or both teeth, on one or both toothed surfaces of the chain. It will be understood that this is an endless chain, that it travels over a driving and a driven sprocket and that it may or may not, as the case may be, travel over intermediate gears or sprockets.

The pin is generally or approximately elliptical in cross section. The holes in the various chain links are generally oval or elliptical in cross section and there is clearance between the pin and the holes in the links. Referring to Figure 7, it will be noted that the pintle pin has two

centers of articulation $a$ and $b$. These centers are separated by a definite distance which is a considerable portion of the length of the major axis of the cross section of the pin and a line connecting these two centers is at approximately 90° to the line of chain travel. This connecting line need not be at 90° and must not be parallel to the direction of chain travel if the desired action is to be obtained. The shape of the hole in the eye of the link as shown diagrammatically in Figure 7 is such as to limit the angle of bend in the chain joint to the desired degree. As shown $c$ is the angle of front bend, $d$ is the angle of back bend, and there is no essential relation between the magnitude of these two angles. The contour of the pin and the hole is formed by two generally cylindrical surfaces joined by two inclined surfaces tangent to the cylindrical ones and so related that, as shown in Figure 7, the pintle may engage one side or other of the hole in the link.

In other words, the center of articulation $a$ is associated with the circular wall of the pin $x$, $x^1$, $x^2$, $x^3$, while the center of articulation $b$ is associated with the curved wall of the pin $y$, $y^1$, $y^2$, $y^3$. The points $x$—$y$ are joined by the two straight walls $y$—$z$ and $z$—$x$, inclined to each other and tangent, respectively, to the circles $y$, $y^1$, $y^2$, $y^3$ and $x$, $x^1$, $x^2$, $x^3$. Similarly, the straight walls $y^3$—$z$ and $z$—$x^3$ are inclined to each other and tangent to the circles $x^3$, $x^2$, $x^1$, $x$ and $y^3$, $y^2$, $y^1$, $y$. The contour of the hole in the link is somewhat similar. Angular movement of the pin and link results in a rotary movement of the opposed cylindrical faces of pin and hole and will cause the straight sided pin walls $y$—$z$ and $z$—$x$ (Fig. 7) to come out of contact with the wall of the hole as movement takes place about the center of articulation $a$ or $b$, the pin tending to move into contact with the opposed side of the pocket.

In other words, the angular movement of the pin and the link is limited in opposed directions by direct contact between the flat surfaces on opposed sides of pin and hole. When the chain travels along a straight line, the contact is between the flat surfaces. These flat surfaces being not subject to sliding friction do not wear rapidly and consequently the rate of increase of pitch length of the chain in service is substantially less than with other types of construction. As the chain deflects in or out the sprockets, limited relative rotation of pin and link takes place but this rotation is localized always at the curved bearing surfaces. Wear at that point does not affect pitch length and this limited rotation immediately brings one or other of the spaced pivot centres into play and tends to resist angular displacement of the general length. The normal tendency of the chain is to be straight with the flat surfaces in contact. Lateral deflection immediately throws the pivot point away from the normal tension line of the chain and so the tension at each link is applied through a lever arm equal to the distance between the pivot point and the neutral or tension line of the chain thus giving the tension of the chain an immediate mechanical advantage tending to throw the chain back into straight alignment.

It is to be observed that, no matter what the relative angular position of the links with respect to one another may be, the line of tension passing through each link cannot, under any circumstances, intersect either of the curved lines bounding the aperture in said link.

When the chain is wrapped around the sprocket, the angular movement of the link and pin is the usual one and it makes no difference that the pivot centre is to one side or other of the neutral line, the chain wraps just as well and the wear is still concentrated on the curved surfaces which do not affect pitch length, there being no friction on the flat surfaces which are in engagement when the chain links are parallel and in alignment.

The fact that the pin is irregular and the hole is irregular and that the pin can rock in the hole results of course in positively limiting or preventing relative angular movement of pin and link on both sides of the neutral line after a predetermined angular excursion has been made. This opposes to chain thrash first a yielding resistance to cushion the action and second a positive resistance to prevent angular displacement of the chain and link. Under some circumstances the chain can be so built that rather wide angular movement is permitted in both directions. Under other circumstances the chain can be built so that back bend in a direction opposite to the direction to bends around the sprockets is minimized. It might even perhaps be entirely prevented but that is ordinarily not desirable.

Referring to Figures 8 and 9, Figure 8 shows the chain in a straight line with the tension line passing through the centres $a^1$ $a^2$ $a^3$ $a^4$ $a^5$ and $a^6$, this being the manner in which the chain theoretically ought to operate. The centres $b^1$ $b^2$ $b^3$ $b^4$ $b^5$ $b^6$ are not in line of tension and at this time have no function. If the chain is deflected as shown in Figure 9, the line of tension is now shifted so that it runs through $a^2$ $b^3$ $b^4$ $a^5$ and the shifting of the line of tension laterally is equal to the

amount $f$, whereas the shift of the chain is equal to the amount 8.

In the conventional type of chain when the chain is laterally deflected or angularly displaced so that the centre of the chain is displaced from the straight line joining the pitch circle of two sprockets, the centre line of the chain and the line through which the tension exerted on the chain passes are both deflected by the amount $g$, whereas in my chain, if the centre line of the chain is shifted to $g$, such lateral displacement of the chain will, by reason of the angular displacement of individual links, result in a further shift (equal to $f$) of the line through which the tension of the chain is applied, thus enabling the chain tension to act on each individual link through a relatively great lever arm to force individual links back into alignment and so to force the whole chain bodily back into alignment with the imaginary line joining the two pitch circles.

As indicated in some of the drawings, while the chain may be built up merely of pintles and links, the same effect can be obtained, as shown in Figures 10, 11 and 12, by the use of liners. In this case the link B has the pin $B^1$. The aperture in the link is divided into two segments by the lugs $B^2$ $B^3$, the outer segment having the liner $B^4$ tightly fitted therein, and free to travel in the wider space between the lugs $B^2$ $B^3$, of the adjacent links. Thus the adjacent chain links are tied together by these liner segments and the operation of the pivot pin and liner segment combination is substantially the same.

In Figure 13 a slightly modified form is shown wherein the pin $A^{12}$ is fixed in one link but gets its play exclusively in the adjacent link, as indicated, that is, the pin $A^{12}$ fixed in the left hand end of the link $A^{22}$ will have play in the aperture $A^{23}$ in the right hand end of the link $A^{21}$. The aperture $A^{24}$ in the link $A^{22}$ is similar to the aperture $A^{23}$ in the link $A^{21}$.

In the modified form shown in Figure 14 every alternate link $F^1$ contains opposed segmental bushings $F^2$ $F^3$, the links F having irregular shaped apertures $F^4$ $F^5$ to permit movement of the bushings $F^2$ $F^3$ associated with the pins $F^6$, so that the action is the same so far as chain operation is concerned but the bushing takes the wear.

I have referred to lateral deflection of the chain. It must be emphasised that by lateral deflection of the chain I am referring to sidewise movement of the chain between any pair of sprockets over which it travels, which movement is different from the articulation of individual related links. By that language I refer to the movement of the chain as a whole between the point of departure and point of entry on opposed adjacent sprockets and it is this violin-string-wise deflection of the chain which takes place in connection with high speed chain and which this invention is intended to obviate.

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed, I declare that what I claim is:—

1. A power transmission chain of the kind in which the articulations between the tension members include means for resisting lateral deflection and consequent thrash in the chain during running, said chain comprising a plurality of tension members or links joined together by pivot pins upon which said tension members are articulated, said tension members being apertured to embrace said pivot pins and each of the latter being so related with the tension members that it has two pivot axes about which articulation of the said tension members can take place, said two pivot axes being located on opposite sides of the neutral tension line of the chain and the line joining said axes being approximately perpendicular to said neutral tension line.

2. A power transmission chain according to claim 1, characterised by the pivot pin receiving apertures in the tension members being longer in a direction perpendicular to the chain than in a direction parallel with it, by the ends of such apertures being bounded by cylindrical surfaces and joined by tangent surfaces, which latter generally intersect the axis of the chain, and by each pivot pin conforming generally to the shape of the aperture and being adapted to rock to a limited extent therewithin to limit relative angular displacement of the tension members.

3. A power transmission chain according to claim 2, characterised by the opposed and coacting surfaces of the pivot pins and tension members being so formed as to permit limited relative regular movement of the links to both sides of the normal tension line of the chain.

4. A power transmission chain according to claim 2, wherein each side of each aperture in the tension members is formed by two straight lines inclined to each other and tangent to the curved ends, the tension line passing between and never intersecting either of the curved lines bounding the aperture.

5. A power transmission chain according to any of the preceding claims, where-

in fixed liners are inserted in the apertures of the tension members on those sides of such apertures where the normal tensional forces act.

6. A power transmission chain as herein described.

7. A power transmission chain constructed and adapted to operate substantially as herein described with reference to the accompanying drawings.

Dated this 19th day of May, 1931.

For the Applicant,
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10, New Court, Lincoln's Inn, London,
W.C. 2.

Redhill: Printed for His Majesty's Stationery Office, by Love & Malcomson, Ltd.—1932.

Fig. 1.

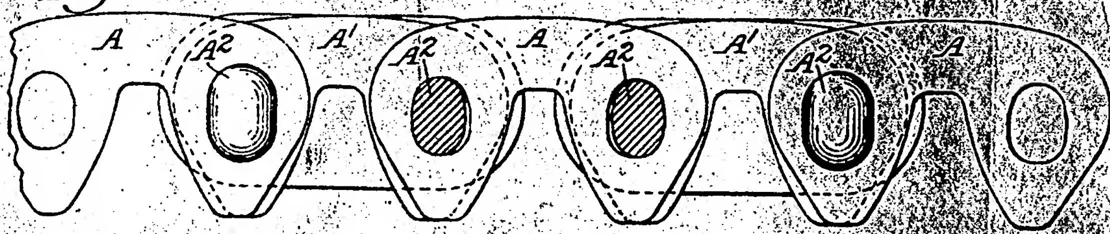



Fig. 2.

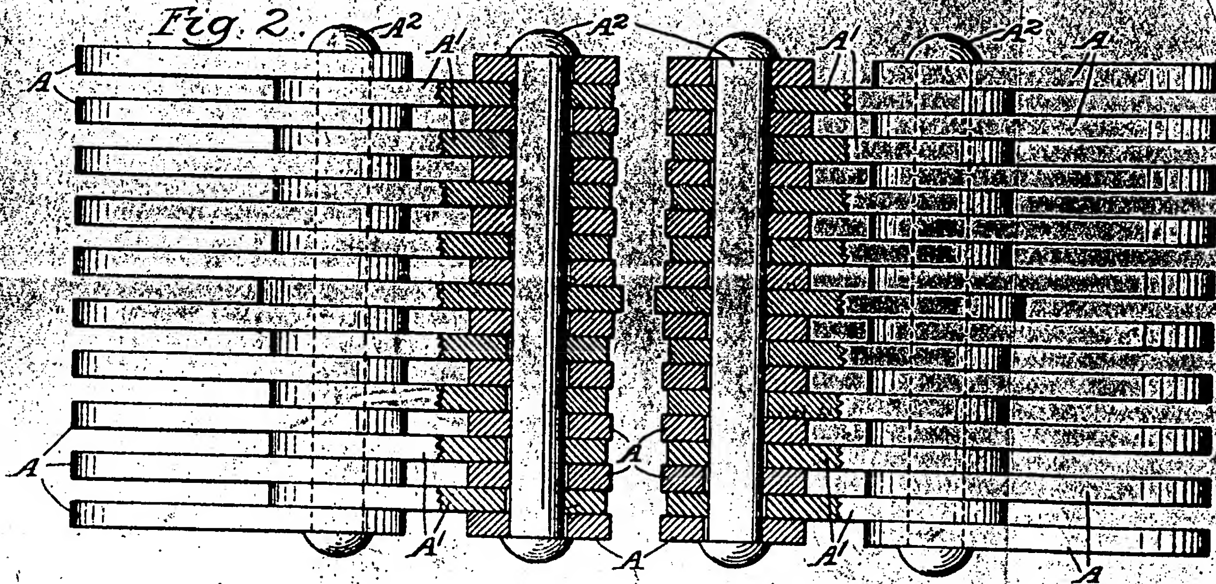



Fig. 3.

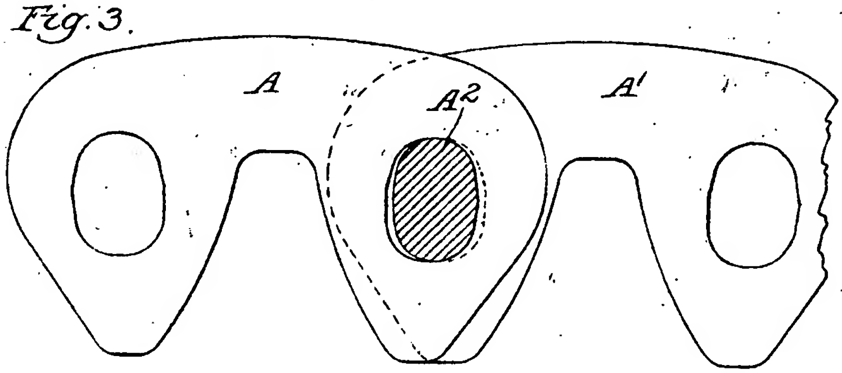
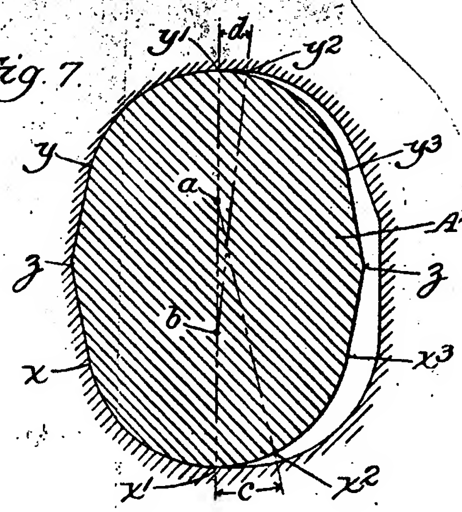



Fig. 7.



2 SHEETS
SHEET 1

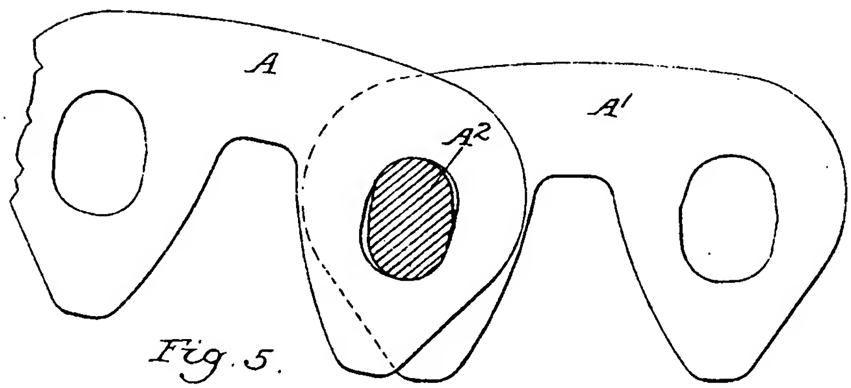



Fig. 5.

Fig. 4.

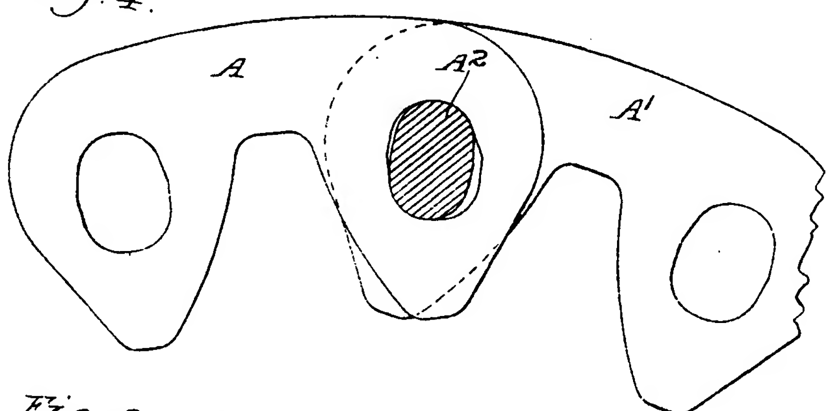
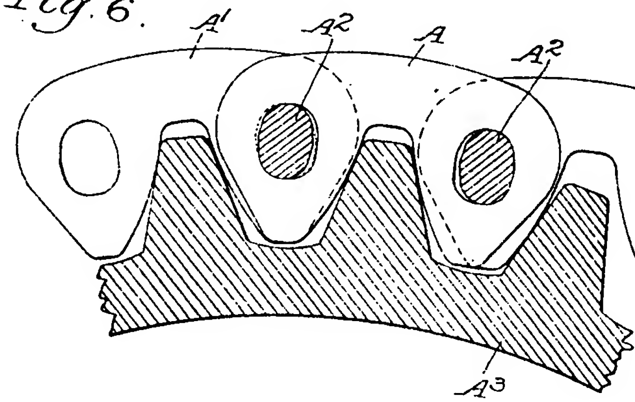



Fig. 6.




Malby & Sons, Photo-Litho

Fig. 8.

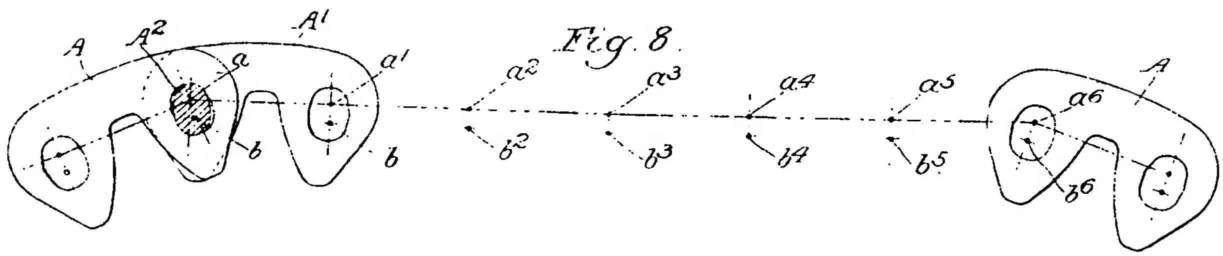



Fig. 9.

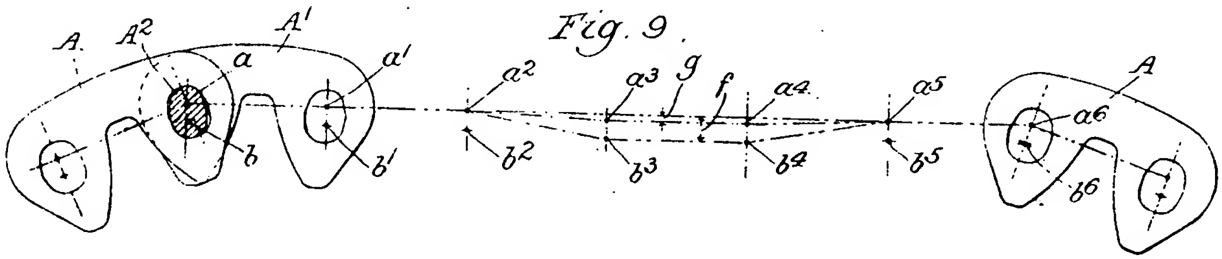



Fig. 10.

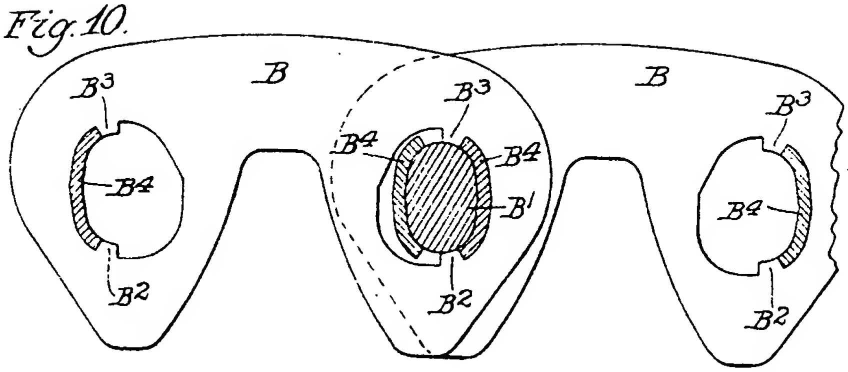



Fig. 11.

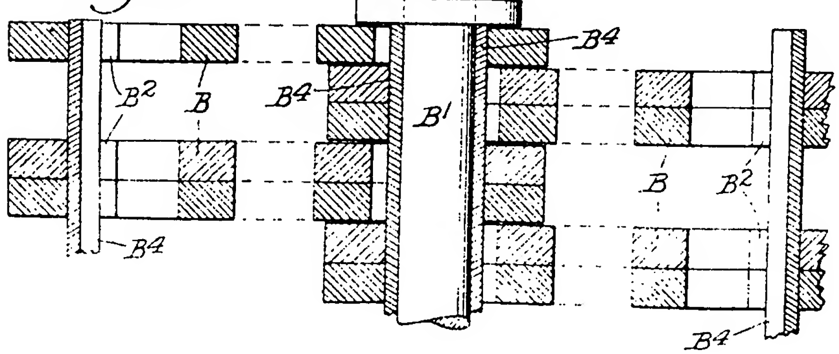


Fig. 13.

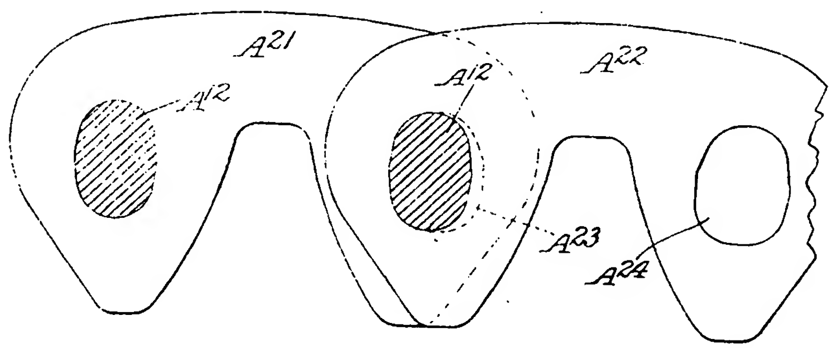



Fig. 12.

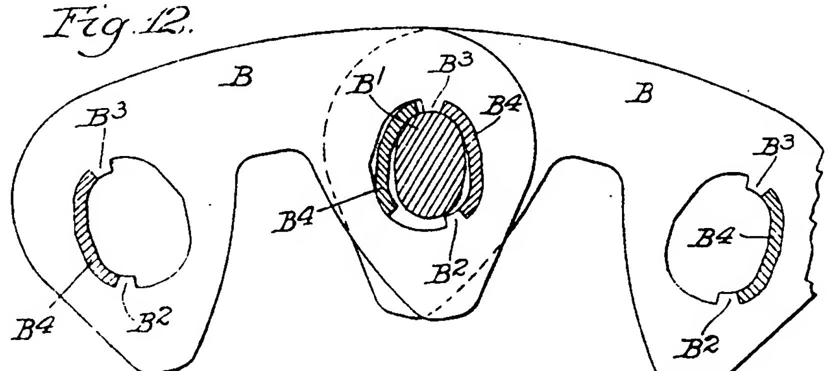



Fig. 14